Sendai Use Case

Microgrid to Supply Power at Multiple Power Quality Levels

(NEDO Sendai Project)

Version 3.2

4 Sep, 2012

1 Descriptions of Function

1.1 Function Name

Multi Power Quality Microgrid (MPQM)

1.2 Function ID

System Level Use Case SEN-1

1.3 Brief Description

This use case describes a Microgrid that enables the supply of power to critical loads at multiple levels of power quality, a *Multi Power Quality Microgrid* (MPQM). These critical loads require higher levels of power quality than are supplied normally by the distribution utility. The Microgrid does this by utilizing Distributed Energy Resources (DER)) and power from the distribution utility (grid) in a mutually complementary manner.

Concept of MPQM

The MPQM is a system that combines distributed energy resources (DER), an Integrated Power Supply (IPS) and a Dynamic Voltage Restorer (DVR)) to supply loads within the Microgrid at multiple levels of power quality.

The concept behind the MPQM is to provide power at multiple levels of quality according to customer needs at a given point in time. It involves the complementary interworking of distributed power sources, including solar power generation systems, and existing power systems, as well as efficient use of batteries and power electronics.

The concept of the MPQM is described in the diagram in Figure 1 below.

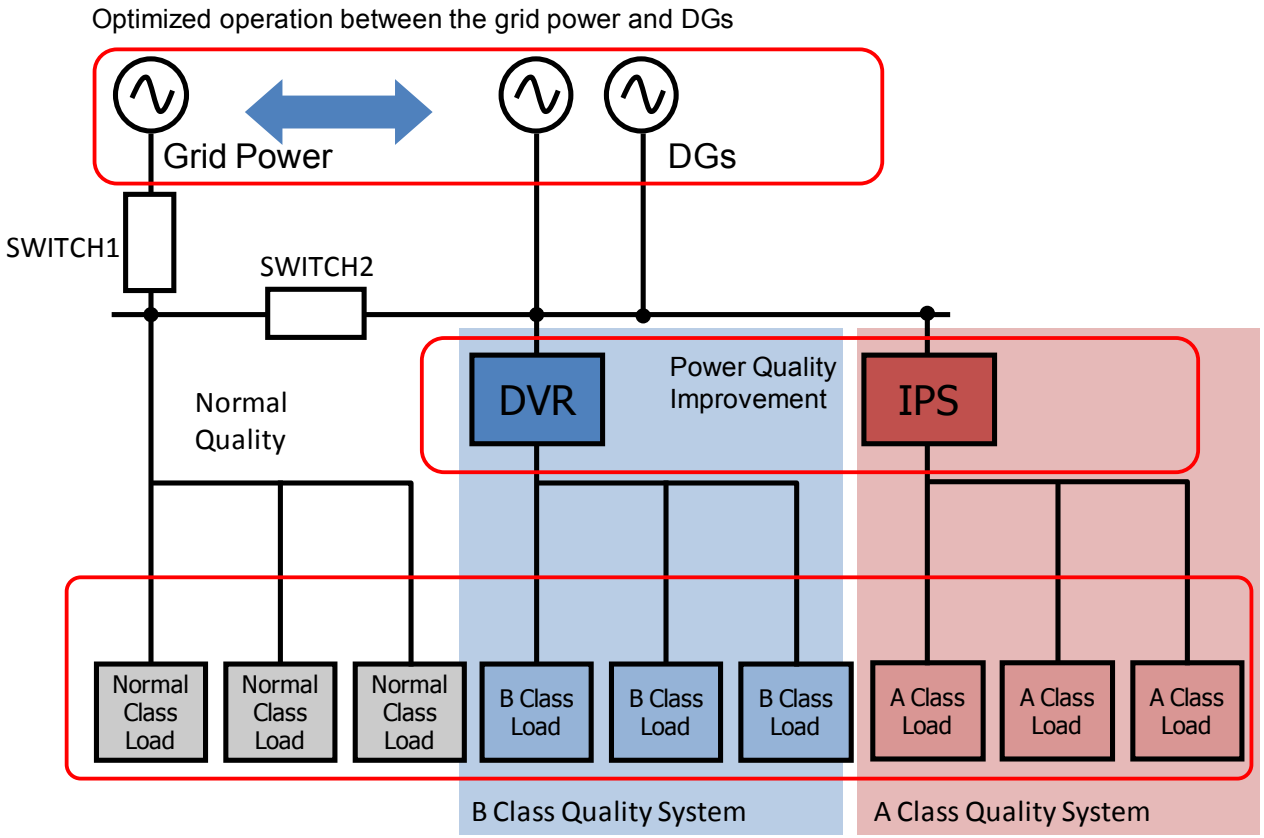

Figure 1 Concept of MPQM

The MPQM comprises three types of distributed generation, fuel cells, gas engines and photovoltaic panels. These are supported by a dynamic voltage restorer (DVR) and integrated power supply (IPS) for power compensation to two levels of power quality, A-Class and B-Class. A "normal" class of power quality is served directly by grid power (distribution utility). The MPQM has two switches, Switch 1 between the MPQM and grid at the PCC and Switch 2 within the MPQM.

Coverage Area of MPQM – Point of Common Coupling

The coverage area of the MPQM and point of common coupling are shown in Fig. 2 below. The coverage area is divided into two different zones: University Zone (blue area) and City-owned Zone (red area).

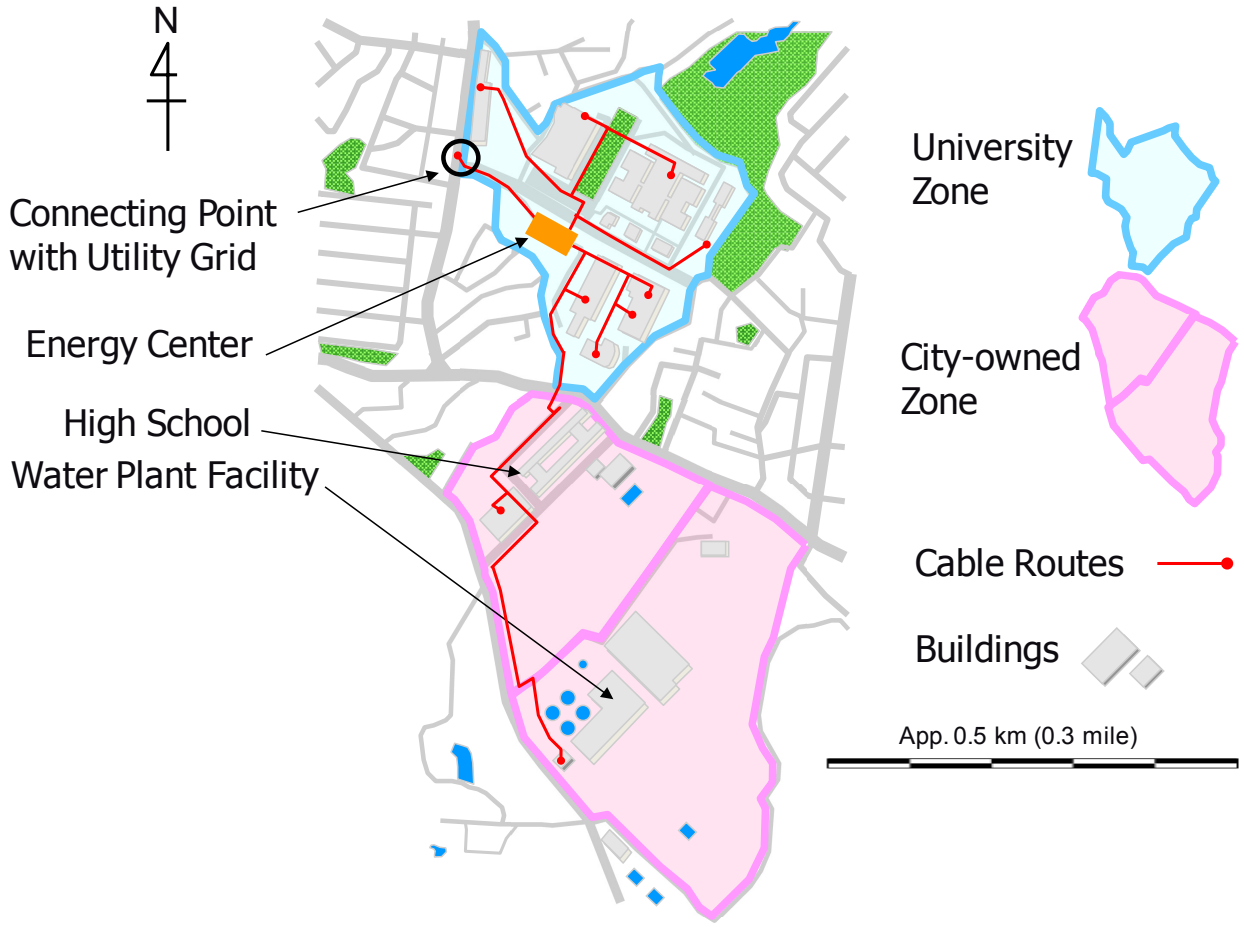

Figure 2 Electricity Supply Areas - MPQM

The PCC between the MPQM and the grid is located in the blue area. Power from the grid cannot be transmitted to the red area due rules on the “resale of electricity” in the interconnection agreement with the local utility (Tohoku Electric Power Co.). Therefore, a “resale prevention” relay is installed to control the power flow, as shown in Fig. 3.

System Configuration of MPQM

The system configuration of the MPQM is shown in Fig. 3. This diagram shows four classes of power quality: (1) A-Class, (2) B-Class, (3) Normal Class and (4) DC. B-CLASS is divided into three classes (B1, B2 and B3). DC has power quality equivalent to A-CLASS.

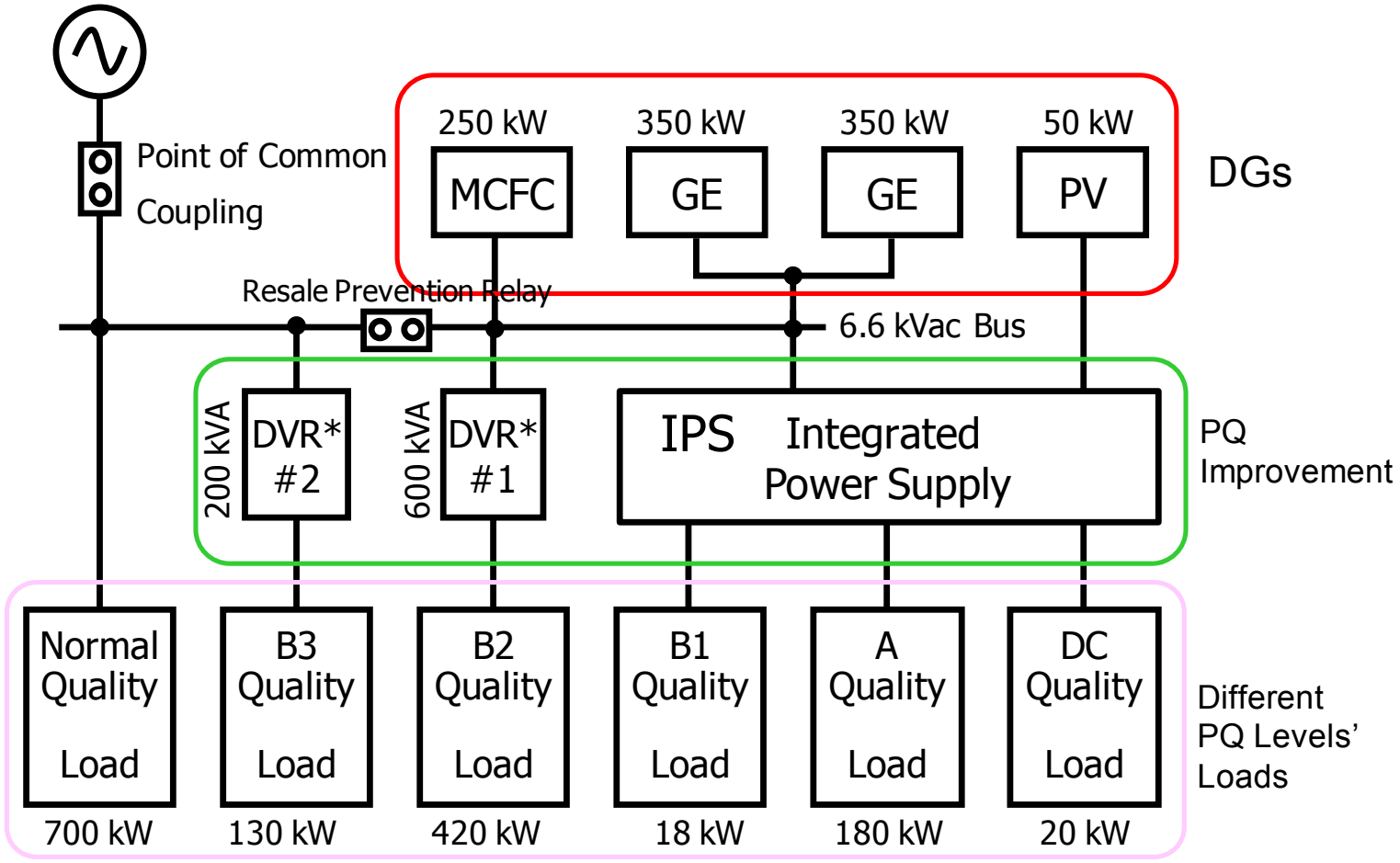

Figure 3 System Configuration of MPQM

There are six power quality classes here. Each description is summarized in Table1. DC Supply, A-Class, B1-Class loads are connected to IPS system. Microgrid has two DVRs, B2 Class loads are connected DVR #1, and B3 Class loads are connected DVR #2. Other characteristics in terms of configuration are same as Fig.1.

The MPQM is connected to the power grid at one point via a circuit breaker (CB1). Basically, it functions through the interworking of three types of distributed power sources (two 350 kW gas engine generator sets, a 250 kW molten carbonate fuel cell, and a 50 kWp solar photovoltaic panel). The output of photovoltaic generation depends exclusively on weather, independent from other controllable generation outputs.

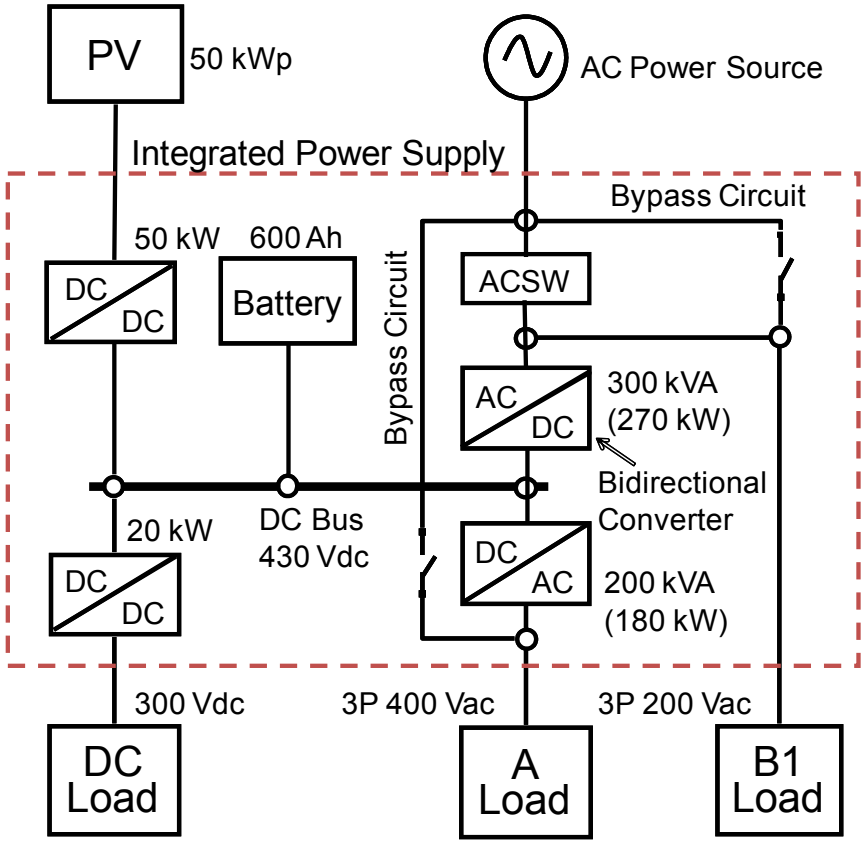

Figure 4 Block Diagram of Integrated Power Supply

The IPS comprises a bidirectional power converter (AC ⇔ DC), a DC-AC inverter, a DC-DC converter (PV) for powering the load, a semiconductor switch (ACSW), and a sealed lead acid battery. There is another DC-DC converter for powering in the IPS. All converters and the battery are connected on the DC-bus in the IPS. The DC-DC (load) and DC-AC converters consume electric power as loads, and the bidirectional and DC-DC (PV) converters supply power. The battery adjusts the power supply on the DC bus.

Multiple Levels of Power Quality for Critical Loads

Power quality requirements for each class of power are summarized in Table 1.

REQUIREMENTS	CLASS				
	DC Power	AC Power			
		A-Class	B1-Class	B2-Class	B3-Class
Interruption	**NI**	**NI**	**Less than 15 ms**	**Less than 15 ms**	**Less than 15 ms**
Voltage Dip	**Y**	**Y**	**Y**	**Y**	**Y**
Outage	**Y**	**Y**	**Y**	**Y***	**-**
Voltage Fluctuations	**Y**	**Y**	**-**	**-**	**-**
Voltage Harmonics	**Y**	**Y**	**-**	**-**	**-**
Voltage Unbalance	**N/A**	**Y**	**-**	**-**	**-**
Frequency Variation	**N/A**	**Y**	**-**	**-**	**-**

Notes:

NI: no interruption; Y: with compensation; - without compensation

* When Gas Engine sets generated

Table 1 Power Quality Requirements by Class of Power

Power Quality Compensation

The MPQM maintains the required power quality even when there is disruption in the interconnected system or when there is load fluctuation during islanding operation.

Power quality for A-Class loads is compensated by the IPS (Integrated Power Supply); power quality for B-Class loads is compensated by the DVR (Dynamic Voltage Restorer); for Normal Class loads there is no compensation for power quality. DC power is higher power quality without any interruptions and disturbances

Class	Voltage Dip Compensation	Waveform Compensation	Power-failure Compensation
A-Class	Compensation by IPS	Waveform compensation	In case of power outage in grid: DER shifts to islanding operation. In case of power outage of DER: Power continues to be supplied from the UPS (battery) embedded in the IPS.
B-Class	Compensation by DVR	No waveform compensation	In case of power outage in grid: DER shifts to islanding operation. In case of power outage of DER: No compensation for outage.
DC power	Compensation by DC/DC converter in IPS	N/A	Independent of the operating modes of the IPS, DC power always supplied from the DC / DC converter. Three types of inputs on the DC-bus by bidirectional inverter, PV panels, and batteries are available.
Normal Class	No voltage dip compensation	No waveform compensation	No compensation or back up for outage.

Table 2 Power Quality Levels Supplied by MPQM

Voltage dip compensation is conducted for A-Class and B-Class loads that require high quality power.

◆A-CLASS

A-CLASS power quality is supplied constantly at voltage waveform level for the most important loads that require power to be supplied without any problem such as distortion, flicker, harmonics. When there is a power failure in the grid, DER shifts its operation to DER-Islanding Mode. Even when the power supply from the DER is no longer available, the power feed is switched instantaneously to Battery-Supply Mode, thus continuing the feed without interruption.

The IPS is a system for compensation of power quality to Class A loads. It has three operational modes:

- **Grid-Connection Mode** compensates voltage dip of A-class loads when the MPQM is interconnected with the distribution system.
- **DER-Islanding Mode** supplies electricity to A-class load from the DER in the event of distribution system outages.
- **Battery-Supply Mode** supplies electricity to A-class load from the battery embedded in the IPS when DER stops.

◆B-CLASS

B-CLASS power quality is supplied by combining the DVR (Dynamic Voltage Restorer) with STATCOM, capacitor. When there is a power failure in the grid, DER shifts to an islanding operation, as in the case of A-CLASS when the power supply from DER is interrupted.

◆Normal CLASS

Normal Class power quality is supplied at a power quality level equivalent to that of the distribution utility.

MPQM has two switches, “Switch 1” at the PCC and “Switch 2” that separates Normal Class from A and B Classes. These switches operate to manage the islanding operation of the MPQM when there is an outage on the grid.

NOTE: The MPQM was conceived as a research demonstration project, *Sendai Demonstration of Multiple Power Quality Supply System* by the New Energy and Technology Development Organization (NEDO) in 2004. The MPQM was installed at Tohoku Fukushi University, Sendai, Miyagi Prefecture, Japan. The research was conducted by NTT Facilities, Inc. (NTT-F); the Microgrid continues operations under the management of NTT-F.

1.4 Narrative

The MPQM is designed to supply power to customers at the level of power quality that meets their needs. The MPQM can continue to supply power at a high power quality level when the DER is grid-connected or when the grid suffers from an outage and the DER is in an islanding operation mode.

The functions of the MPQM can be described in four stages as follows:

Stage 1: DEMAND AND GENERATION DAY-AHEAD FORECAST, GENERATION SCHEDULING AND OPERATING DAY ADJUSTMENTS

The MPQM utilizes power from the DER in a mutually complementary manner with the distribution system by scheduling generation according to forecasted demand, adjusted for real time operations. In the MPQM the EMS calculates the Day-Ahead demand forecast (half-hourly, for twenty-four (24) hour period prior to the beginning of the Operating Day); prepares a generation schedule; and reviews and adjusts generation on the Operating Day, the actual day, including hours ending 0100 to 2400, during which energy is flowing. The forecasts are made in the EMS by using archives of load profiles provided the previous day based on past month records.

Based on the demand forecast and the PCC reference value, the monitoring and control server plans a Day-Ahead target output value (half-hourly, for 24 hours) for DER. . This target output value is then conveyed to the DER as a command.

The demand forecast value is reviewed on the Operating Day. If there is a gap between the demand forecast value and the actual demand record obtained from RTU installed in the load, the generation schedule incorporating the target output value for the DER is adjusted.

The interconnection agreement between the microgrid and distribution utility has a provision that prohibits the reverse power flow from the MPQM to the grid. In accordance with this provision, a reference value is set for power flow at the PCC and incorporated into the operation schedule of the DER.

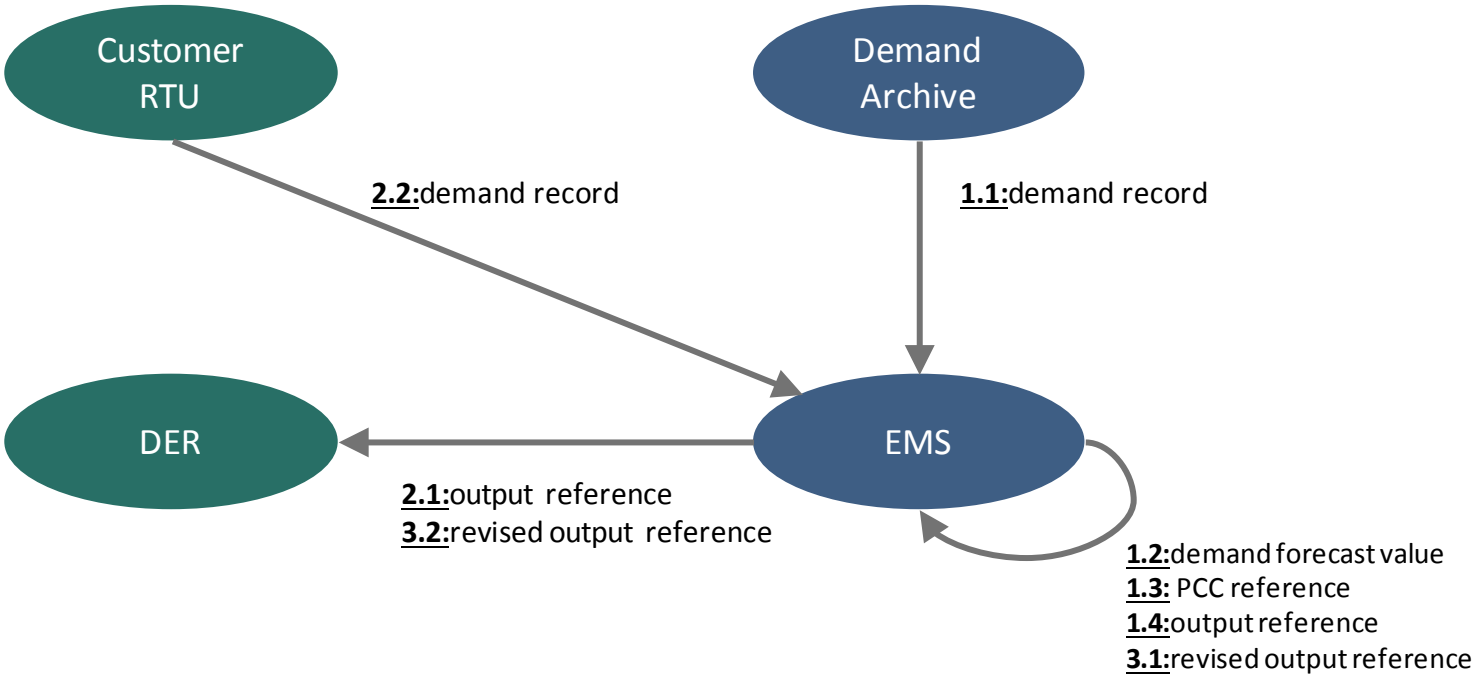

Figure 5 Diagram of Stage 1

Stage 2-1: A-CLASS POWER QUALITY SUPPLY

For the A-CLASS POWER QUALITY SUPPLY, power quality is compensated constantly at voltage waveform level by the IPS. Even when the power supply from the DER or commercial grid is no longer available, feeding is continued without interruption by switching the operation instantaneously to the back-up system of the IPS which contains a UPS (battery). This function is implemented by the IPS.

The IPS has three operation modes: i) Grid-Connection Mode, ii) DER--Islanding Mode and iii) Battery-Supply Mode. Usually, it is operated in Grid-Connection Mode.

- **Grid-Connection Mode** compensates voltage dip of A-class loads when the MPQM is interconnected with the distribution system.
- **DER-Islanding Mode** supplies electricity to A-class loads in collaboration with DER Distribution system during distribution system outages.
- **Battery-Supply Mode** supplies electricity to A-class from the battery embedded in the IPS when DER stops.

When the IPS detects a dip in grid voltage, it shifts into Battery-Supply Mode and discharges the storage battery to supply power to A-CLASS loads.

In case of a power outage in the distribution utility, Switch 2 is opened as soon as it detects the outage. Once the DER detects the opening of Switch 2, it shifts to DER-Islanding Mode. Once the EMS detects that Switch 2 is open, it sends a command to the IPS to shift to DER-Islanding Mode. The IPS in DER-Islanding Mode starts supplying power to A-CLASS loads in collaboration with the DER and IPS.

If the DER fails due to an accident or malfunction, while in Islanding Mode, the IPS receives a stop signal, shifts to Battery-Supply Mode and starts discharging the storage battery to feed power to A-CLASS loads.

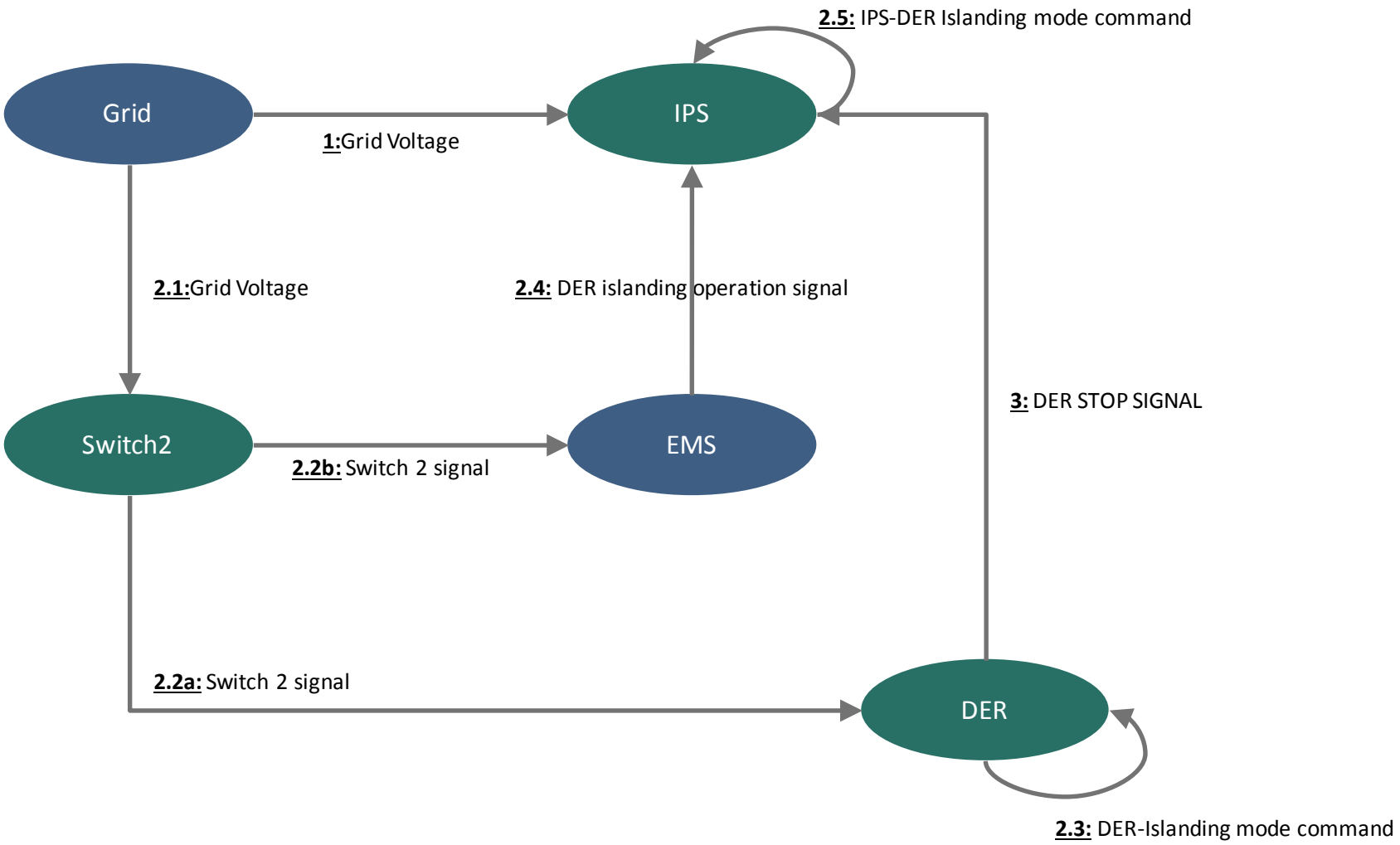

Figure 6 Diagram of Stage 2-1

Stage 2-2: B-CLASS POWER QUALITY SUPPLY

For B-CLASS POWER QUALITY SUPPLY, voltage dip compensation is conducted. When an outage occurs in the distribution system, DER and DVR shift to the DER-Islanding Mode as in the case of A-CLASS, but a discontinuation of power supply from DER leads to a power outage.

When a voltage dip occurs and DVR detects it, it generates compensation voltage for B-CLASS loads.

In case of power outage in distribution system, Switch 2 opens automatically as soon as it detects the outage. Then DER detects the opening of the Switch 2 and shifts into the DER-Islanding Mode. The DER in the islanding operation starts supplying power to A-CLASS and B-CLASS loads simultaneously.

If the DER fails due to an unintended event while in DER-Islanding Mode, power supply to B-CLASS is no longer available.

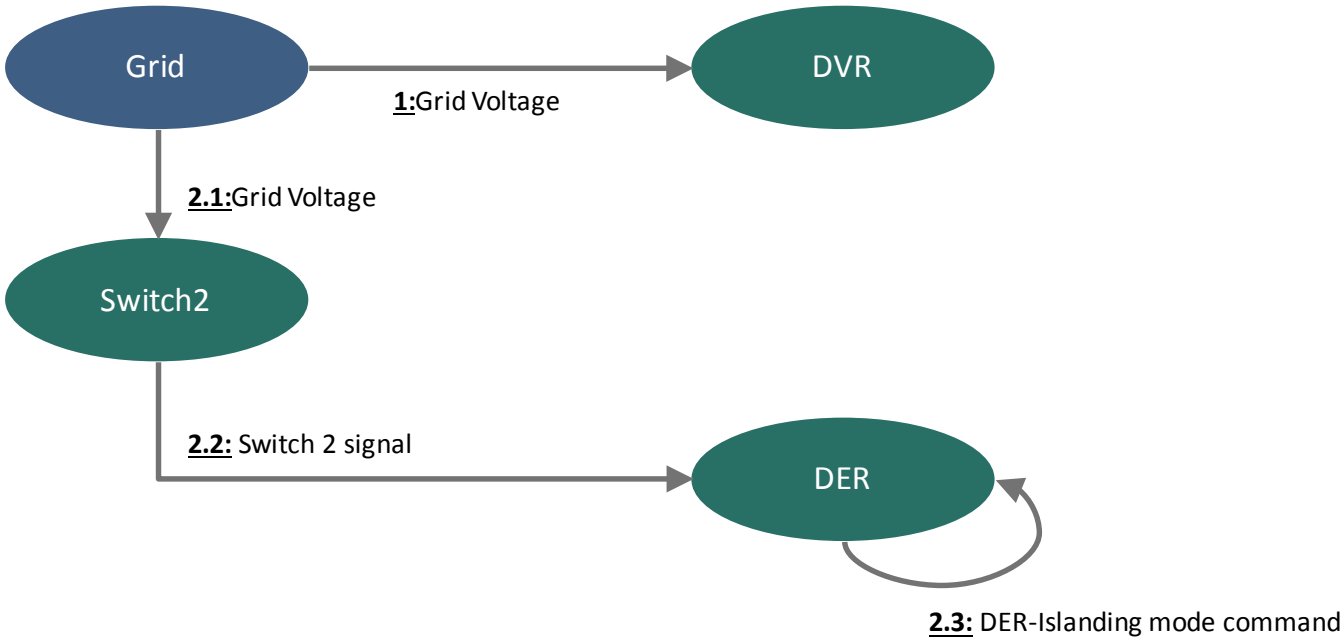

Figure 7 Diagram of Stage 2-2

Stage 3: AUTOMATIC SHIFT TO ISLANDING OPERATION AT GRID OUTAGE, AND AUTOMATIC SHIFT TO CONNECTED OPERATION AT GRID RESTORATION

Stage 3-1: AUTOMATIC SHIFT TO ISLANDING OPERATION AT GRID OUTAGE

The MPQM is in grid-connected operation at normal times. When there is an outage in grid, Switch 2 promptly detects the outage from grid voltage information and opens. In the same way, Switch 1 opens. As soon as Switch 2 opens, DER shifts to Islanding Mode.

Stage 3-2: AUTOMATIC SHIFT TO CONNECTED OPERATION AT GRID RESTORATION

When the distribution utility restores power at the PCC, Switch 1 detects the change of voltage and closes. The DER then synchronizes the voltage and frequency of the islanding system with the grid's voltage and frequency. DER closes Switch 2 as soon as it detects that voltage/frequency is synchronized between the islanding system and grid.

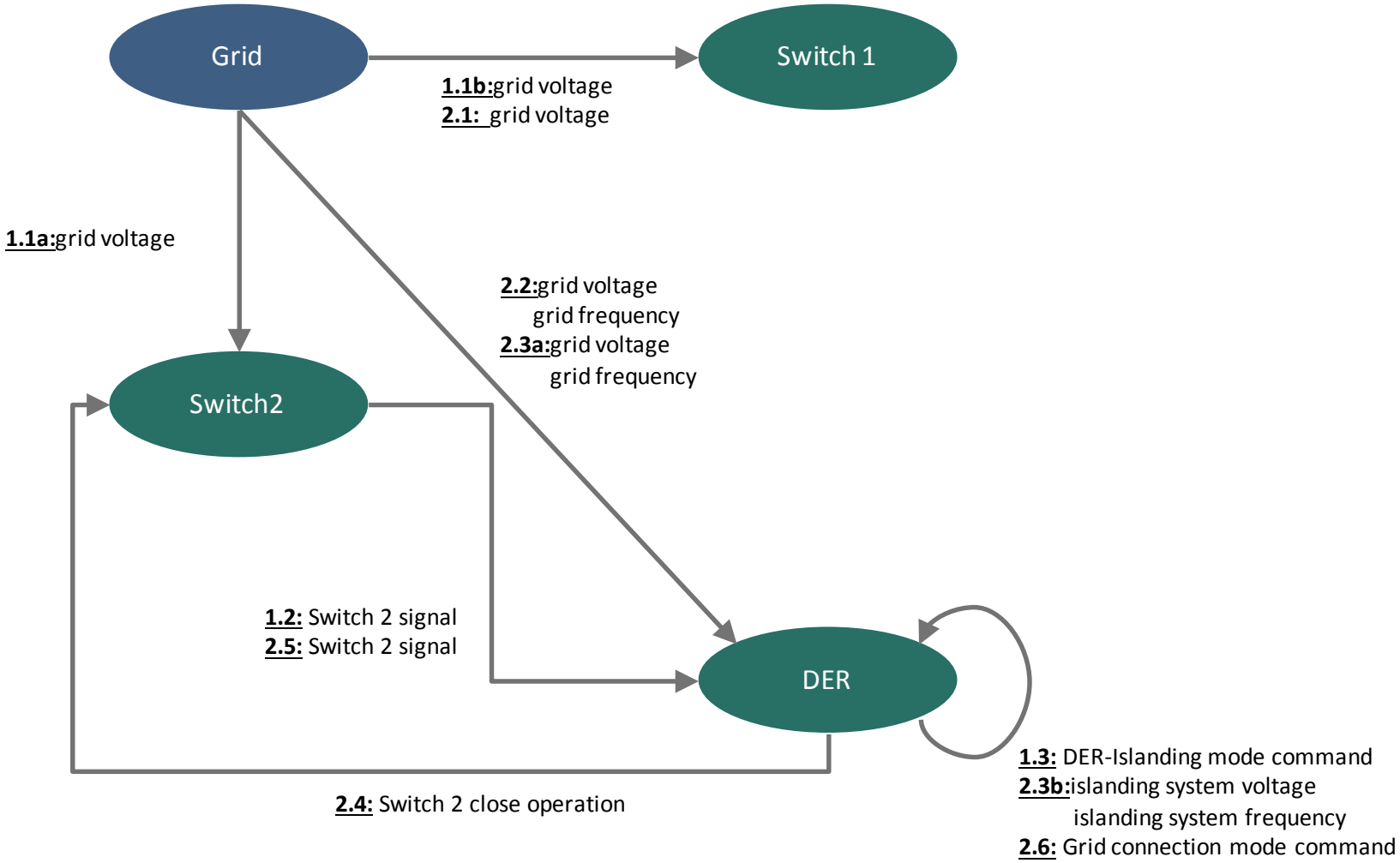

Figure 8 Diagram of Stage 3

1.5 Acronyms

MPQM	Multi Power Quality Microgrid
IPS	Integrated Power Supply
UPS	Uninterruptible Power Supply (battery)
DVR	Dynamic Voltage Restorer
STATCOM	Static Synchronous Compensator
PCC	Point of Common Coupling
DER	Distributed Energy Resource
RTU	Remote Terminal Unit
DC	Direct Current
EMS	Energy Management System

1.6 Actor (Stakeholder) Roles

Actor Name	*Actor Type (person, organization, device, system, or subsystem)*	*Actor Description*
EMS	System	System that monitors and controls MPQM
Demand Archive	System	Archive that stores past demand record data of MPQM
DER	Resource	DER within MPQM DER has two operation modes: Grid-Connection Mode and Islanding Mode. It is operated in the Grid-Connection Mode normally, but once it detects the grid outage, it shifts to the Islanding Mode.
Customer RTU	Device	Device installed in MPQM's customer's premise to measure their power usage
IPS	System	Integrated Power Supply or IPS has three operation modes: Grid-Connection Mode, DER-Islanding Mode and Battery-Supply Mode The IPS contains a storage battery. In the event of a voltage dip or failure in power supply from DER, power is supplied from the storage battery (Battery-Supply Mode). This system is installed in A-CLASS system.
DVR	System	Implemented in STATCOM, the Dynamic Voltage Restorer (DVR) generates compensation voltage when it detects a voltage dip. This system is installed in B-CLASS system.
Switch 1	Device	Switch between MPQM and grid
Switch 2	Device	Switch within MPQM. See Fig. 1 for the location
Grid	System	Distribution utility

1.7 Information exchanged

Information Object Name	*Information Object Description*
demand record	Demand record is the data to be measured by customer RTU and stored in Demand Archive.
demand forecast value	Future demand forecast calculated by EMS.
PCC REFERENCE	Target power flow value at PCC in MPQM.
output reference	Output reference of DER (prepared by EMS).
revised output reference	EMS reviews and revises the output reference for DER; when there is a gap between the demand forecast value and the actual result, a revised output reference is set.
Grid Voltage	Voltage in distribution system.
Grid frequency	Frequency in distribution system.
DER-ISLANDING MODE COMMAND	Command within DER. Based on this command, DER shifts into Islanding Mode.
IPS-DER ISLANDING MODE COMMAND	Command within IPS. Based on this command, IPS shifts into DER-Islanding Mode.
DER STOP SIGNAL	Signal to inform IPS that DER stopped.
Switch 2 signal	Signal to inform open/close status of Switch 2.
Islanding system voltage	Voltage of islanding system when DER is in islanding operation mode.
Islanding system frequency	Frequency of islanding system when DER is in islanding operation mode.
Switch 2 Close Operation	Operational Signal of Closing Switch 2 from DER.

1.8 Activities/Services

Activity/Service Name	*Activities/Services Provided*
A-CLASS POWER QUALITY SUPPLY	A-CLASS POWER QUALITY SUPPLY provides power quality compensation at voltage waveform level on a constant basis. Even when the power supply from the DER or grid is no longer available, the feeding can be continued by switching to the back-up system without any interruption.
B-CLASS POWER QUALITY SUPPLY	B-CLASS POWER QUALITY SUPPLY provides voltage dip compensation. In case of grid outage, DER shifts into the islanding mode as in the case of A-CLASS, but the power goes out when the supply from DER is no longer available.

1.9 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Contract with A-CLASS customer	MPQM operator has a contract with A-CLASS customer to provide A-CLASS power supply.
Contract with B-CLASS customer	MPQM operator has a contract with B-CLASS customer to provide B-CLASS power supply.
Interconnection Agreement with distribution utility	There is an interconnection agreement on reverse power flow prevention between the distribution utility and MPQM owner/operator.

2 Step by Step Analysis of Function

2.1 Steps to implement function – Stage 1: Demand and generation forecast, generation scheduling and on-the-day review

2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Demand Archive	Demand Archive stores past demand record data of MPQM.
PCC REFERENCE	PCC REFERENCE is set by Microgrid operator.

2.1.2 Steps – Demand and generation forecast, generation scheduling and on-the-day review

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.1	18:15 previous day	EMS	Read past demand record data.	EMS reads past demand record data.	Demand Archive	EMS	demand record	
1.2		EMS	Demand forecast	EMS forecasts demand.	EMS	EMS	demand forecast value	
1.3		EMS	Read PCC REFERENCE	EMS reads PCC REFERENCE.	EMS	EMS	PCC REFERENCE	
1.4		EMS	Prepare output reference	EMS prepares DER's output reference.	EMS	EMS	output reference	
2.1	0:00 on the day	EMS	Command output reference	Command output reference to DER	EMS	DER	output reference	Command at 1-minute interval.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
2.2		EMS	Collect demand record	Collect demand record obtained from customer RTU	customer RTU	EMS	demand record	
3.1	When there is a gap between the demand forecast and actual result.	EMS	Review output reference	Recalculate output reference for DER in consideration of the gap between demand forecast and actual result.	EMS	EMS	revised output reference	
3.2		EMS	Command revised output reference	Command revised output reference to DER.	EMS	DER	revised output reference	Command at 1-minute interval.

2.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
MPQM	MPQM maintains stable supply inside because it is provided power from the DER and grid in a mutually complementary manner (between DER and grid).

2.2 Steps to implement function – Stage 2-1: A-CLASS POWER QUALITY SUPPLY

2.2.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Grid and MPQM	Grid and MPQM are operated connected to each other.
DER	DER is operated normally.

Actor/System/Information/Contract	*Preconditions or Assumptions*
A-CLASS customer	A-CLASS customer is provided with stable energy supply just before an outage.
IPS	IPS carries out voltage compensation at voltage waveform level on a constant basis.

2.2.2 Steps – A-CLASS POWER QUALITY SUPPLY

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1	Voltage dip	IPS	Detect voltage dip / Shift into Battery-Supply Mode	IPS detects voltage dip, shifts into Battery-Supply Mode and discharges inner storage battery.	Grid	IPS	Grid Voltage	
2.1	Grid outage	Switch 2	Detect outage / Open Switch 2	Switch 2 detects grid outage and opens.	Grid	Switch 2	Grid Voltage	
2.2a		DER	Detect opening of Switch 2	DER detects opening of Switch 2.	Switch 2	DER	Switch 2 signal	
2.2b		EMS	Detect opening of Switch 2	EMS detects opening of Switch 2.	Switch 2	EMS	Switch 2 signal	
2.3		DER	Shift into DER islanding operation	DER shifts into islanding operation.	DER	DER	DER-ISLANDING MODE COMMAND	
2.4		EMS	Send islanding operation signal	EMS sends command signal to IPS to shift into islanding operation.	EMS	IPS	DER islanding operation signal	

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
2.5		IPS	Shift into control mode for IPS islanding operation	IPS shifts into DER-ISLANDING MODE.	IPS	IPS	IPS-DER ISLANDING MODE COMMAND	
3	DER stops when in DER islanding operation	IPS	Detect DER stoppage / Shift into Battery-Supply Mode	IPS detects DER stoppage, enters into Battery-Supply Mode and discharges the inner storage battery.	DER	IPS	DER STOP SIGNAL	

2.2.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
A-CLASS customer	A-CLASS customer is provided with stable power supply even in the event of voltage dip, grid outage and/or DER stoppage.

2.3 Steps to implement function – Stage 2-2: B-CLASS POWER QUALITY SUPPLY

2.3.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Grid and MPQM	Grid and MPQM are operated connected to each other.
B-CLASS customer	B-CLASS customer is provided with stable energy supply just before a voltage dip.

2.3.2 Steps – B-CLASS POWER QUALITY SUPPLY

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1	Voltage dip	DVR	Detect voltage dip / generate compensation voltage	DVR detects voltage dip and generates compensation voltage.	Grid	DVR	Grid Voltage	
2.1	Grid outage	Switch 2	Detect outage / Open Switch 2	Switch 2 detects grid outage and opens.	Grid	Switch 2	Grid Voltage	
2.2		DER	Detect opening of Switch 2	DER detects opening of Switch 2.	Switch 2	DER	Switch 2 signal	
2.3		DER	Shift into DER islanding operation	DER shifts into islanding operation.	DER	DER	DER-ISLANDING MODE COMMAND	

2.3.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
B-CLASS customer	B-CLASS customer is provided with stable power supply even in the event of voltage dip or grid outage.

2.4 Steps to implement function – Stage 3: Automatic shifting into islanding operation at grid outage and automatic shifting into connected operation at grid restoration

2.4.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Grid	Power outage occurs in grid.
Switch 1	Switch 1 is closed.
Switch 2	Switch 2 is closed.

2.4.2 Steps – Automatic shifting into islanding operation at grid outage and automatic shifting into connected operation at grid restoration

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes
1.1a	Grid outage	Switch 2	Detect outage / Open	Switch 2 detects grid outage and opens.	Grid	Switch 2	Grid Voltage	
1.1b		Switch 1	Detect outage / Open	Switch 1 detects grid outage and opens.	Grid	Switch 1	Grid Voltage	
1.2		DER	Detect opening of Switch 2	DER detects opening of Switch 2.	Switch 2	DER	Switch 2 signal	
1.3		DER	Shift into islanding operation	DER shifts into islanding operation.	DER	DER	DER-ISLANDING MODE COMMAND	
2.1	Grid recovers	Switch 1	Detect restoration / Close	Switch 1 detects grid restoration and closes.	Grid	Switch 1	Grid Voltage	
2.2		DER	Synchronization	DER synchronizes voltage and frequency	Grid	DER	Grid Voltage・Grid frequency	

				of islanding system to the grid.				
2.3a		DER	Detect voltage and frequency of grid.	DER detects voltage and frequency of grid.	Grid	DER	Grid Voltage・ Grid frequency	
2.3b		DER	Detect voltage and frequency of islanding system.	DER detects voltage and frequency of islanding system.	DER	DER	Islanding system voltage・ Islanding system frequency	
2.4		DER	Close Switch 2	DER closes Switch 2 on confirming the synchronization.	DER	Switch 2	Switch 2 close operation	
2.5		DER	Detect closing of Switch 2	DER detects closing of Switch 2.	Switch 2	DER	Switch 2 signal	
2.6		DER	Shift into grid connected operation	DER shifts into grid connected operation.	DER	DER	Grid-Connection Mode Command	

2.4.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
Grid	Grid restored.
Switch 1	Switch 1 is closed.
Switch 2	Switch 2 is closed.

3 Auxiliary Issues

3.1 References and contacts

ID	Title or contact	Reference or contact information
[1]	An Overview of SENDAI Experimental Study Project Experimental Study Project - Power feeding test with Multiple quality levels -	Intelec05 (International Telecommunications Energy Conference 05)
[2]	Use of DC power for data centers in Japan	EPRI DC Power Production, Delivery and Use Workshop June 1-2, 2006, George Washington University, Washington, D.C.
[3]	Study on field demonstration of multiple power quality level	Intelec06 (International Telecommunications Energy Conference 06)
[4]	Power Quality Assurance by using Integrated Power System for Micro Grids	Intelec06 (International Telecommunications Energy Conference 06)
[5]	Stability Analysis of High-Voltage DC Power Distribution System, including Long Feeders	Intelec07 (International Telecommunications Energy Conference 07)
[6]	Effect of breaking High Voltage Direct Current (HVDC) circuit on Demonstrative Project on Power Supply Systems by Service Level in Sendai	Intelec07 (International Telecommunications Energy Conference 07)
[7]	Demonstrative Project on Power Supply Systems by Service Level in Sendai, Japan	Electrical Power Quality and Utilization 2007
[8]	HVDC power distribution on NEDO Sendai Demonstration	IEEE 2008 Systems Packaging Japan Workshop
[9]	The characteristics of Power Supply Systems by Service Level - Development of a new power plant for multiple power quality level feedings -	ICEE2008 (The International Conference on Electrical Engineering 2008)

[10]	Study on Demonstrative Project on Power Supply Systems by Service Level in Sendai, Japan - Verification of Stabilizing Islanding Grid by Integrated Power Supply -	ICEE2008 (The International Conference on Electrical Engineering 2008)
[11]	Study on Demonstrative Projects on Power Supply Systems by Service Level in Sendai, Japan - Results of Field Demonstration using Back to Back Voltage Source Converters -	ICEE2008 (The International Conference on Electrical Engineering 2008)

3.2 Revision History

No	Date	Author	Description
1.0	02/24/2012	K. Hirose A. Fukui T. Shimakage A. Matsumoto Y. Idaka K. Hiroe	First Draft
1.1	03/14/2012	J. Reilly	Review and comment
2.0	03/19/2012	H. Irie	Revision
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